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TYPE OF ENGINE TO EMPLOY.

By M. Hamel.

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TYPE OF ENGINE TO EMPLOY.*

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The engine of a commercial airplane must, above all, be sure and durable. It seems therefore that we must use engines with vertical cylinders or in the V form with quite a small angle. The types which should, in our opinion, be given the preference, are, according to the power required, either the eight-cylinder vertical or the sixteen-cylinder V-engine with reduction gear.

The reduction gear is considered essential, because the rotational speed of engines now in use is lowered by the necessity of imparting a high degree of efficiency to the propeller. A reduction gear giving the propeller the proper speed and the engine a high rotational speed, would enable an increase in weight, provided the ratio is large enough (at least 2). We may yet see a propeller revolving at 1000 r.p.m. driven by an engine rotating at 3000 r.p.m. As to the durability of such an engine, automobile engines have been run for ten years with a stroke of 180 mm and a speed of 2800 r.p.m. Such an engine can be made lighter than a slow engine of the same power. Another advantage is that, the stroke-volume being small, the cylinders fill better and the ratio of bore to stroke can be improved without exceeding suitable piston speeds. The fuel consumption will also be reduced, which is important from the commercial point of view.

The number of engines on large commercial airplanes should not be less than four, in order to provide for sufficient power.

* From Premier Congrès International de la Navigation Aérienne, Paris, November, 1921, Vol. II, pp. 58-61.

in case one of them should fail. In our opinion, six should be the maximum number, under present conditions, in order to avoid excessive complication of the power transmission. Assuming a unit power of 600 HP, this would give us a total of 3600 HP. Installation of engines in the cells must be absolutely prohibited, by reason of the considerable loss of power entailed. For example, take a twin-engine 400 HP airplane flying at 145 km (90 miles) per hour. The resisting surface of each engine is about two-thirds of a square meter. The resistance will be $K S V^2$ or $(0.08 \times 0.66 \times 40^2) \times 2 = 138.96$ kg which, at a speed of 40 m/sec, represents work of $T = R \times V = 138.96 \times 40 = 5.558$ kg/m/sec, or 90 HP or 25% of the total power.

This arrangement has, moreover, the defect of fatiguing the cells at the points where the engines are attached, in case of a hard landing. An interesting solution of this problem is found in the four-engine Breguet. For higher powers, we consider it necessary to have more than one propeller. Fig. 1 represents two propellers driven by four engines, the power being transmitted through bevel gears located within the wing, an arrangement made possible by new methods of construction.

We consider it very important to fly at a high altitude for the sake of the gain in speed, which considerably reduces the cost of the trips. It is accordingly necessary to employ engines whose power is independent of variations in altitude and consequently to install compressors, which may be either independent or driven by the exhaust gases (Rateau).

It then becomes very difficult to utilize this motive power. Since the propeller is moving in a rarer medium, it is necessary to increase, by some artificial device, the apparent power of the propeller, as the altitude increases. For this purpose, the use of propellers of variable pitch or diameter has been proposed, but we think these methods should be rejected for the present, on account of the difficulties involved. In our opinion, it would be better to use a reduction gear with several ratios, i.e. to give an airplane the speed changes of an automobile. After calculating our propeller for flight at a given altitude, - as an automobile is calculated for direct drive on level ground - we can reduce the revolution speed, as the air becomes denser, the same as the speed of an automobile is reduced, when the resistance increases. In this way, airplane and propeller are always kept in accord, since the forward speed of the airplane is proportional to the revolution speed of the propeller, since the power absorbed by the airplane varies as the cube of its speed and since the power absorbed by the propeller likewise varies as the cube of its revolution speed.

Let us take an example from Eiffel's works. An airplane has the following characteristics:

P_m , 260 HP; V , 160 km/hr; N , 1500 r.p.m.

Assuming that a compressor maintains a constant power up to 5000 meters, the apparent power for which the propeller must be computed will be

$$P_m \times \frac{S_0}{S} = 260 \times 1.67 = 437 \text{ HP.}$$

An airplane, which previously flew 160 km per hour, will then acquire a speed of

$$160 \times \sqrt[3]{\frac{437}{235}} = 160 \times 1.19 = 260 \text{ ?}$$

or about 200 km/hr, or a gain of 20%.

The propeller must then answer the following conditions:

$$V = 200 \text{ km/hr, } P = 437 \text{ HP, } N = 1500 \text{ r.p.m.}$$

It is quite evident that we cannot take off with this propeller, if the ratio of its r.p.m. to that of the engine remain constant, but if, by a change of the gear, we reduce it to 1250 r.p.m. we have:

$$V = 166 \text{ km/hr, } P_m = 250 \text{ HP, } N = 1250 \text{ r.p.m.}$$

In both these cases the ratio V/nD remains the same and the propeller is consequently well adapted.

Let us now assume that we have succeeded in keeping the engine power constant up to 10,000 meters. The apparent power then becomes

$$P_m = \frac{S_0}{S} = 260 \times 3.02 = 785 \text{ HP.}$$

The speed of the airplane will then be:

$$160 \sqrt[3]{\frac{785}{260}} = 240 \text{ km/hr.}$$

or a gain of 50%.

The propeller becomes

$$V = 240 \text{ km/hr, } P_m = 785 \text{ HP, } N = 1875 \text{ r.p.m.}$$

Thus the cost of a trip can be considerably reduced, in that

it can be made in less time, and also by reason of the increased carrying capacity due to the considerable reduction in the quantity of fuel carried.

It can be readily understood that, if the gear wheels are arranged as shown in Fig. 2, the engine shaft drives the propeller by means of the satellites and their speed ratio will be determined by the ratio of the trains C/F and F'/D' . If, on the contrary C comes inside the internal gear D , the other two shafts will rotate at the same speed.

It is therefore obvious that, with a given airplane, we can obtain an appreciable improvement in efficiency, by flying at high altitudes with the combined use of a compressor and a speed changer, the additional weight being largely offset by the saving in fuel effected. The efficiency of the engine would likewise be improved, since it would not be compelled to drive a propeller at too low a speed.

We referred, in the first paragraph, to 16-cylinder V-engines. This type appears very important to us, because it has enough cylinders to give sufficient power, while retaining the dimensions of normal cylinders. A 100/180 could give 600 HP at 3000 r.p.m., the resulting reduction in weight then being very advantageous. The angle of the V would be 45° . The cylinders would thus be under excellent functioning conditions, particularly as regards lubrication. The propeller drive should be in the center of the engine, so that the torque would be similar to that of a crankshaft with only four cranks.

The fuel consumption of such an engine would be nearly the same as that of an automobile engine, since conditions would be somewhat similar. We should bear in mind, however, that while in aviation 230 grams is consumed per HP/hr, an automobile consumes 170 grams. This difference, for 1000 HP and 10 hours of flight, amounts to at least 500 kg of fuel, which is worth saving.

We also believe it would be worth while to build, for small-powered commercial airplanes or touring airplanes, an engine with six or eight vertical cylinders, with cam shaft on top, this shaft serving at the same time as a propeller drive, as is already the case in certain Renault engines.

This small engine could run at 3000 r.p.m., the propeller making 1500, which is suitable for a propeller of small diameter. Such an engine would have an extremely small cross-section and would be capable of giving excellent service.

We think the radial construction should be abandoned. The rotary engine, excellent from certain points of view, has the disadvantage, for commercial aviation, of a high fuel consumption and necessitates extremely careful construction and upkeep, by reason of the stresses which its very principle compels the parts to undergo. As to the fixed radial, it can only be kept in equilibrium as a double radial, which leads to a very great complication in the valve control and water circulation. The lubrication is likewise more difficult and necessitates a complex system of tubes and a relative solidity. For small powers, however, where

we can employ air cooling and a small cross-section, this engine may be used, but we think an engine with cylinders in a row are much preferable, although weighing more.

In an aircraft engine, too much importance should not be attached to the "dry" weight, but that, on the contrary, we should not hesitate to adopt devices, slight increasing this weight, if they conduce to surer and more economical flight, in order that the airplane may ultimately compete successfully, in the commercial field, with other means of locomotion and thus lead the whole world to the pacific conquest of the air.

Translated by the National Advisory Committee for Aeronautics.

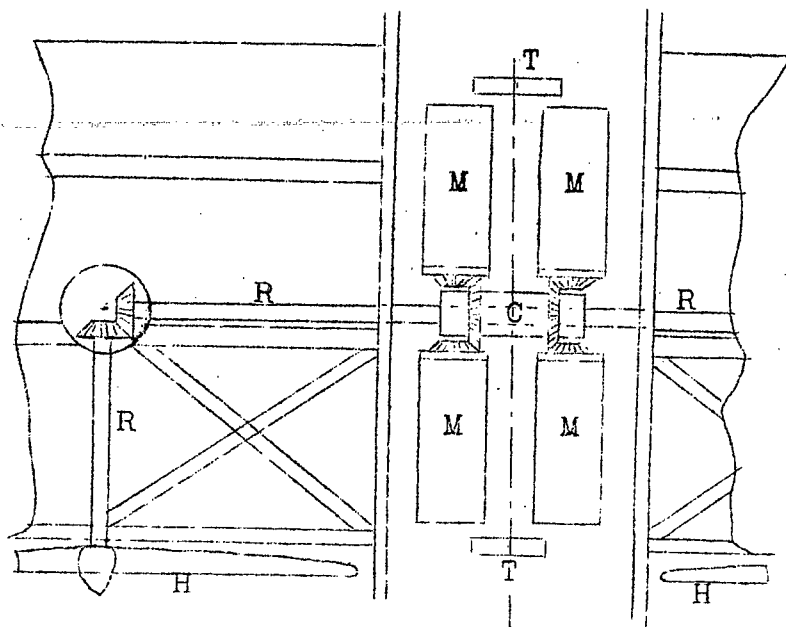


Fig.1

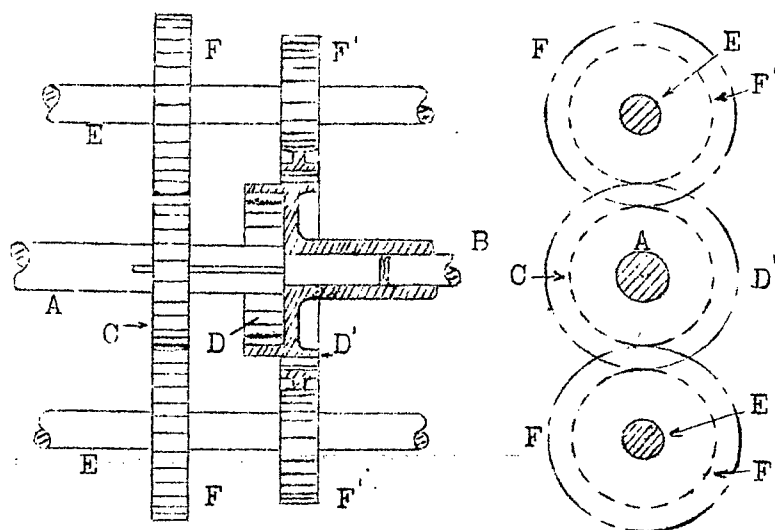


Fig.2

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